

# The Nature of Computing

## ICOM 4995 Lecture 3

Prof. Bienvenido Velez

# Some Inaccurate Yet Popular Perceptions of Computing

- Computing = Computers
- Computing = Programming
- Computing = Software

# Computing = Computers

Computing is about solving  
problems using computers



*A.K.A. The Computing Device View of Computing*

# Computing = Programming

Computing is about writing  
programs for computers



*A.K.A. The Programming Language view of Computing*

# Computing = Software

Computing is not concerned with  
hardware design

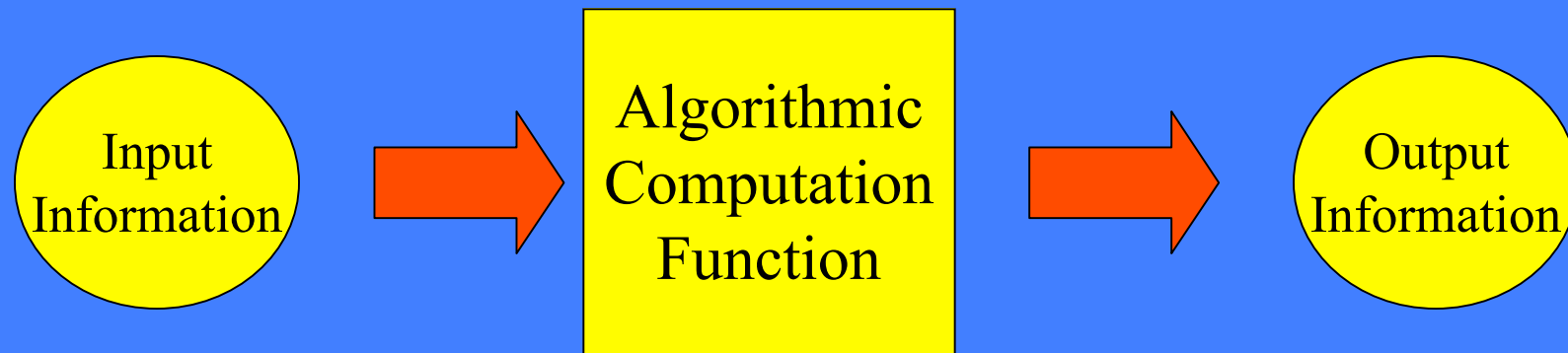


A.K.A. The “Floppy Disk” view of Computing

# Part I - Outline

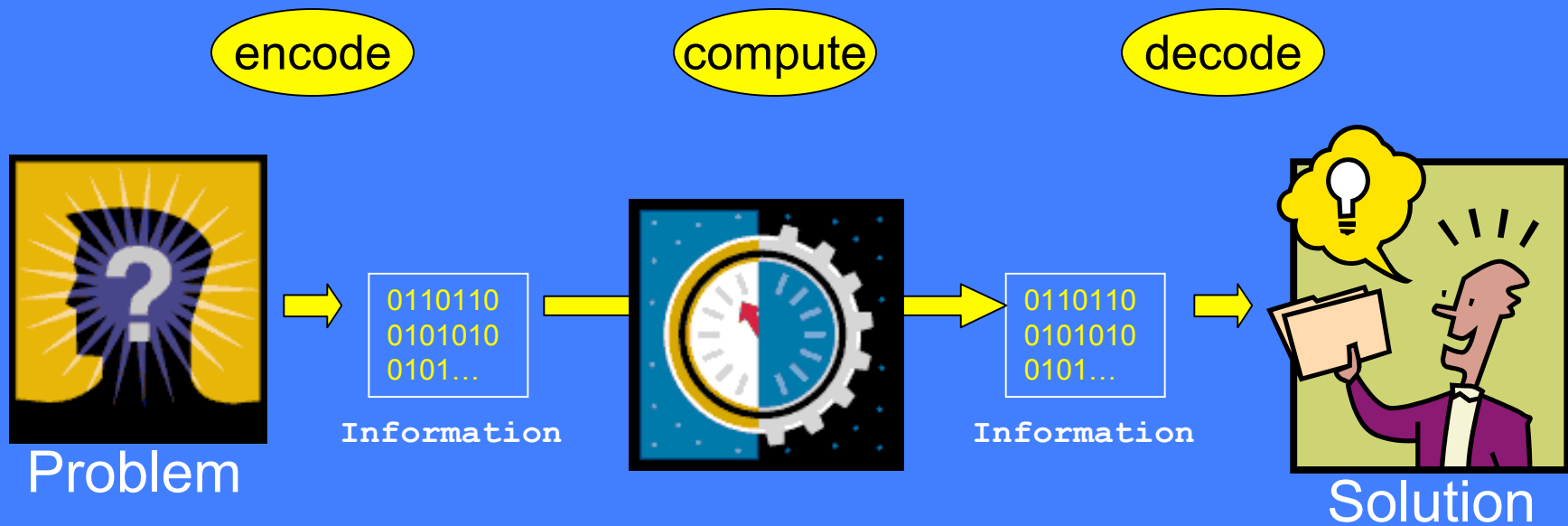
- What is Computing?
- Computing Models and Computability
- Interpretation and Universal Computers
- Church's Thesis

# What is computing then?



Computing is the study of Computation:  
the process of **transforming information**

# The Computation Process

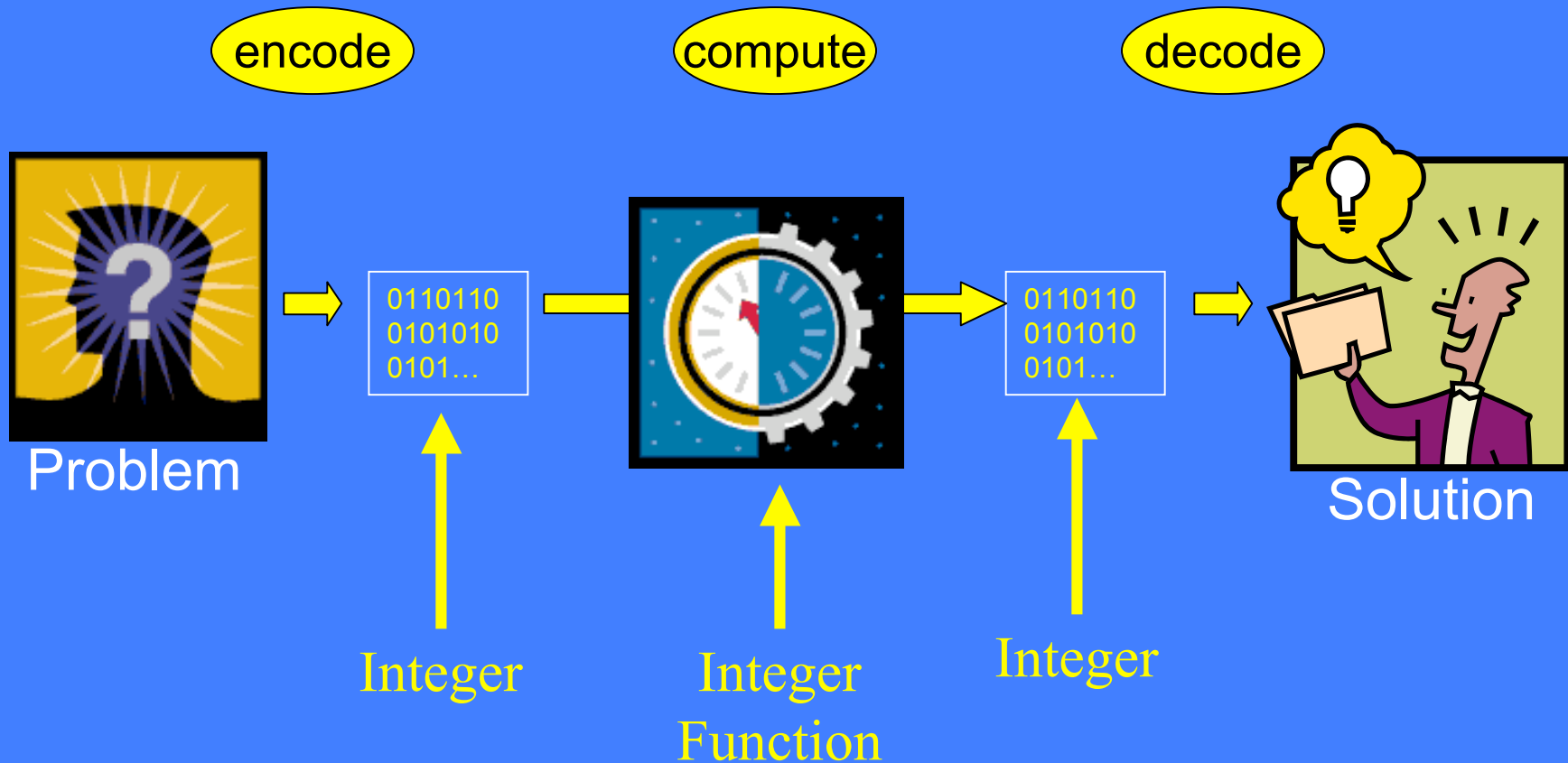




# Fundamental Questions Addressed by the Discipline of Computing

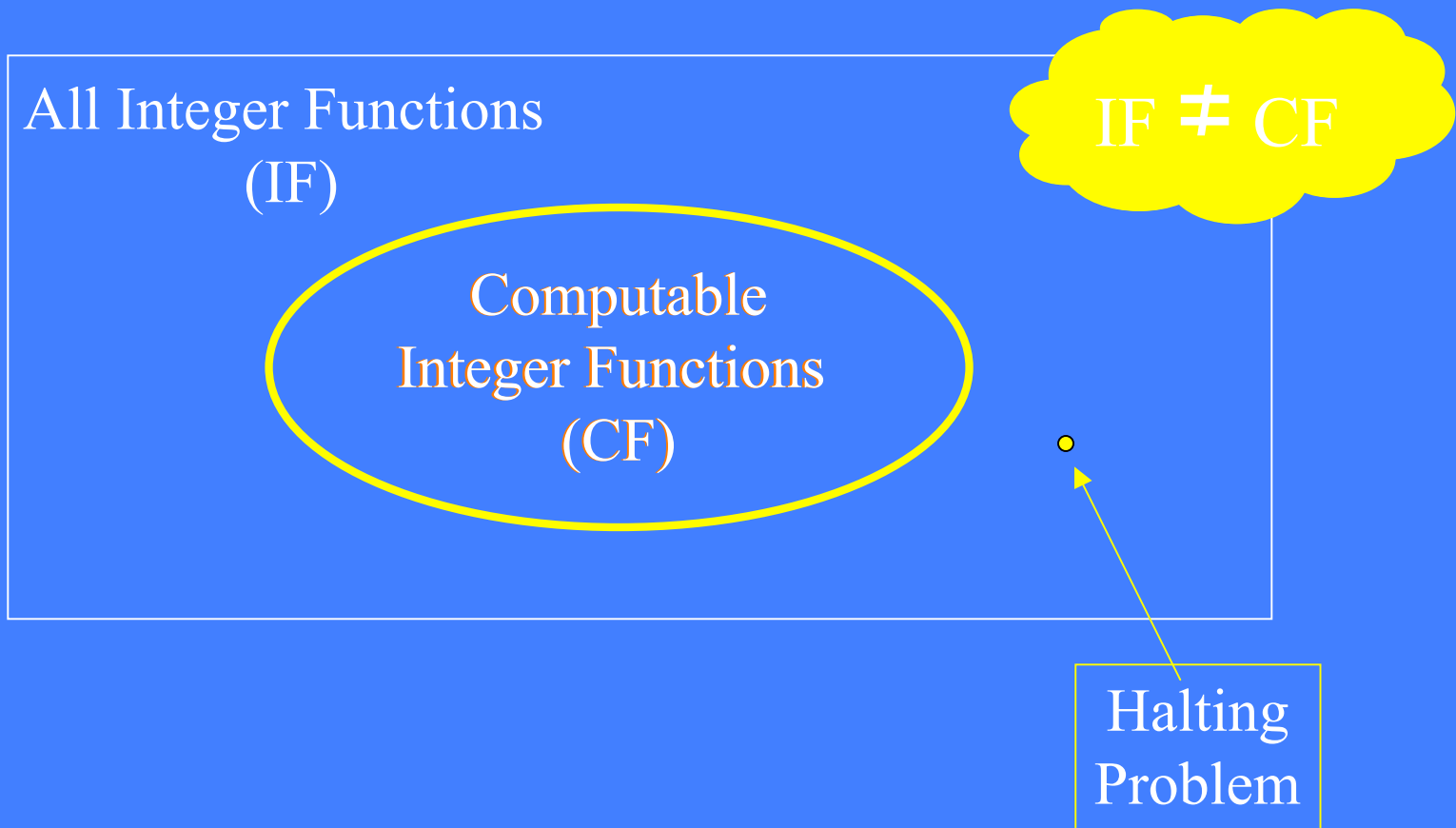
- What is the nature of computation?
- What can be computed?
- What can be computed efficiently?
- How can we build computing devices?

# The Computation Process



**Every Algorithm is in Essence and Integer Function**

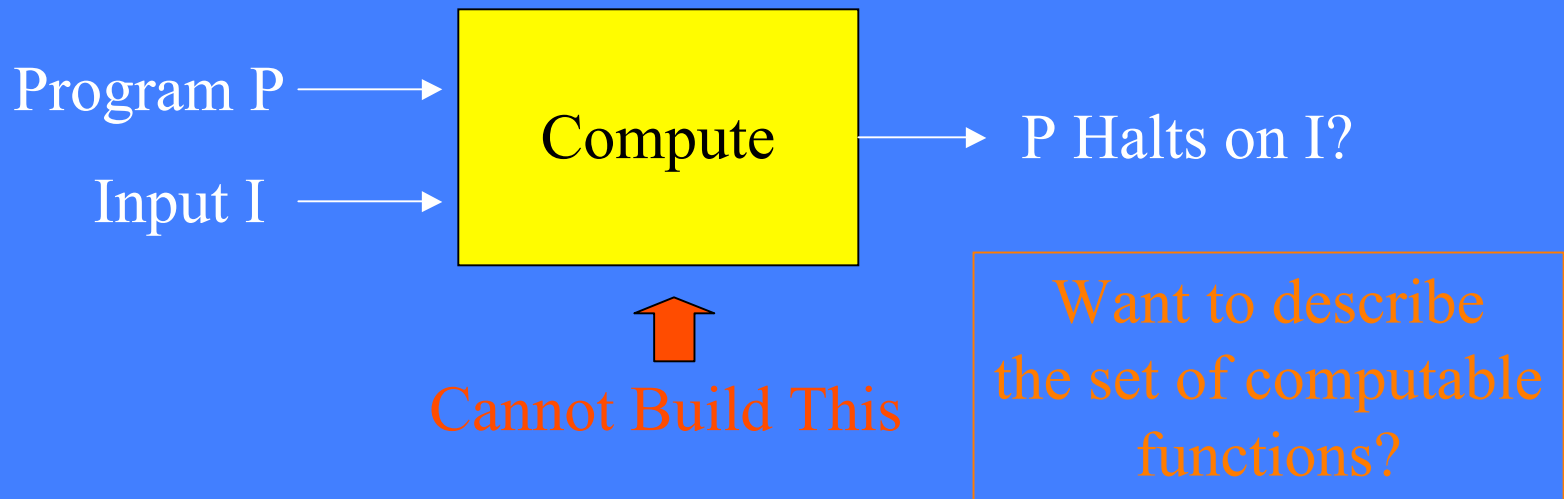
# Computability



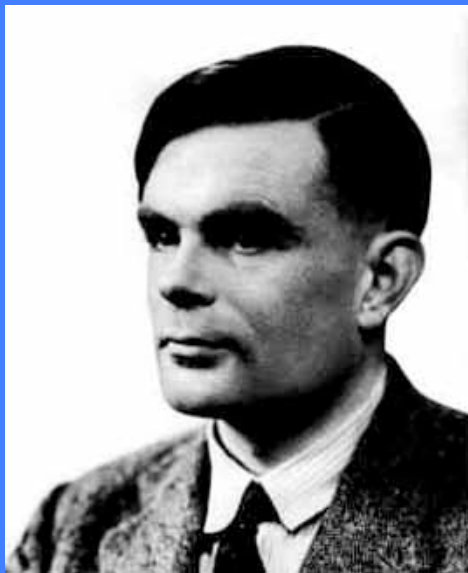
# The Halting Problem

## (Alan Turing 1936)

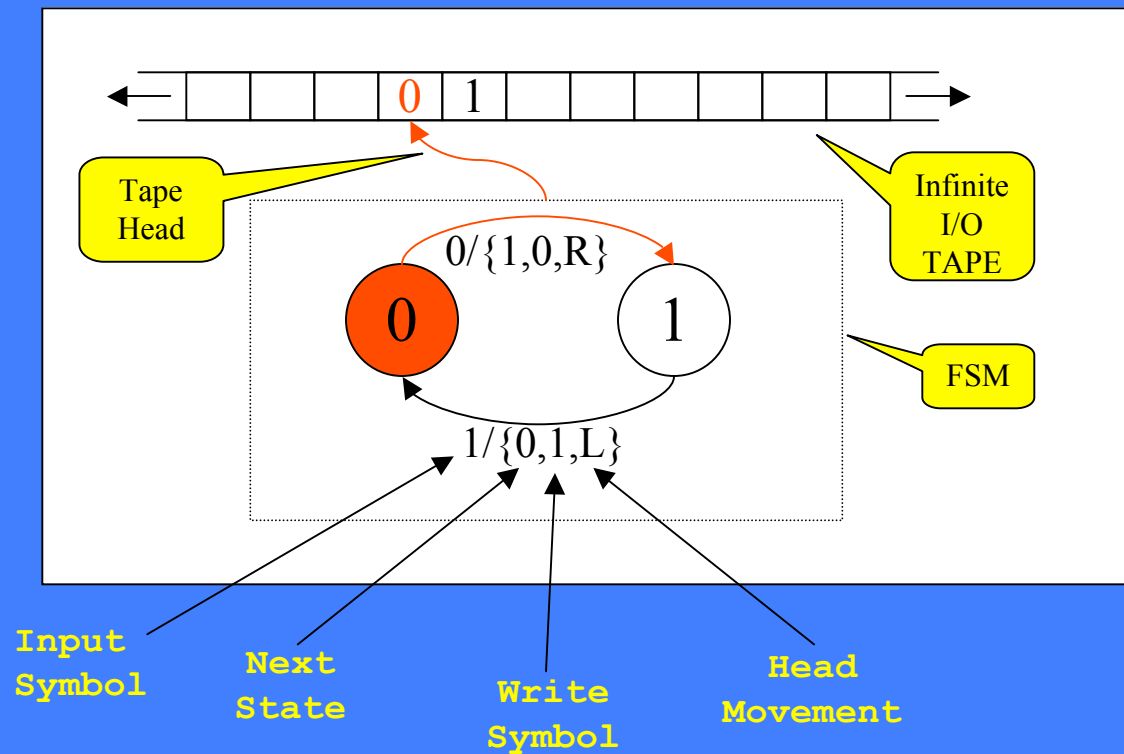
Given a program and an input to the program, determine if the program will eventually stop when it is given that input.



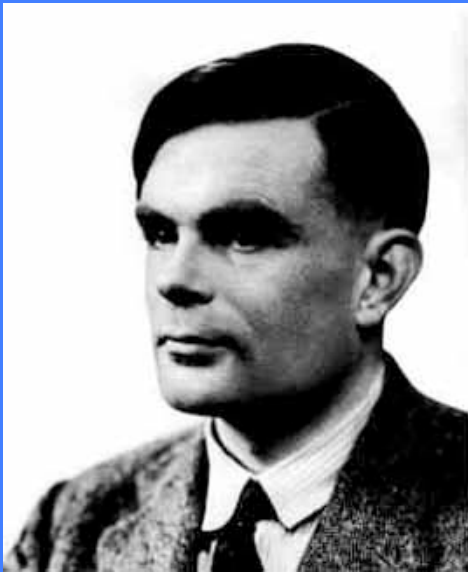
# Mathematical Computers: The Turing Machine (1936)



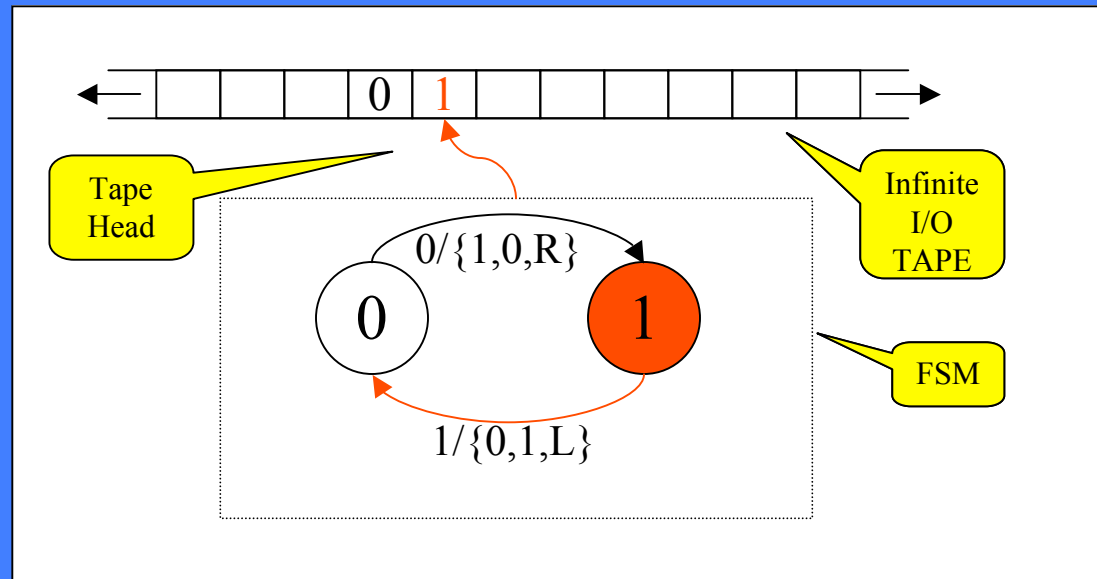
Alan Turing



# Mathematical Computers: The Turing Machine (1936)

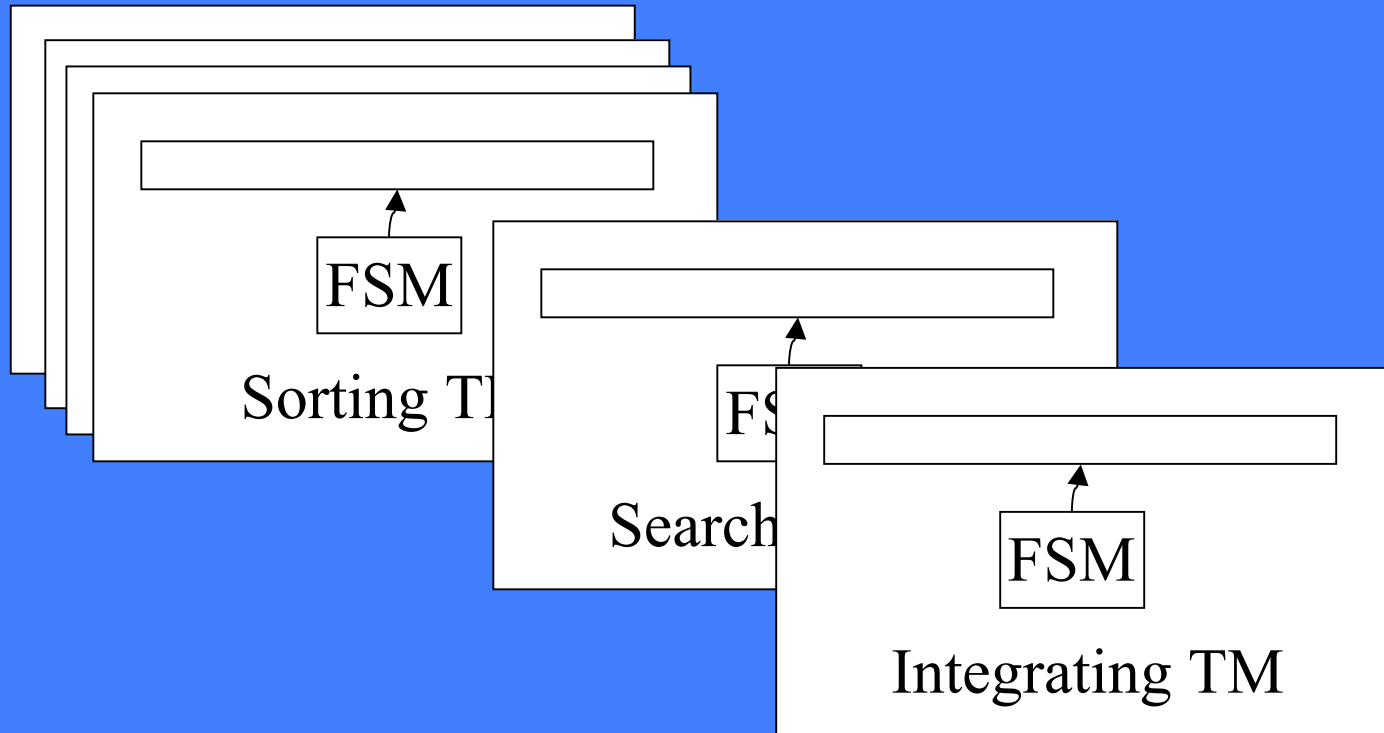


Alan Turing



Turing demonstrated how to solve several problems using his computing model

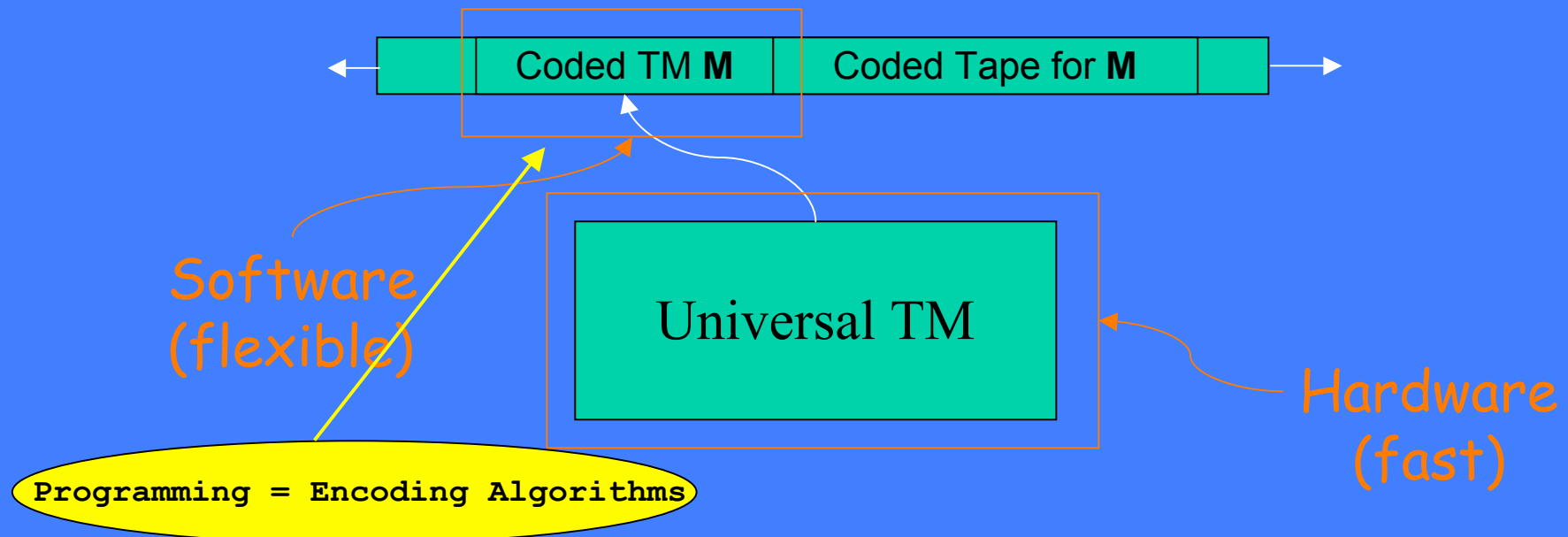
# Ad-hoc Turing Machines



Can we build a general purpose TM?

# The Universal Turing Machine (UTM)

## The Paradigm for Modern General Purpose Computers



- Capable of Emulating Every other TM
- Shown possible by Alan Turing (1936)
- BIG IDEA: **INTEPRETATION!!!**

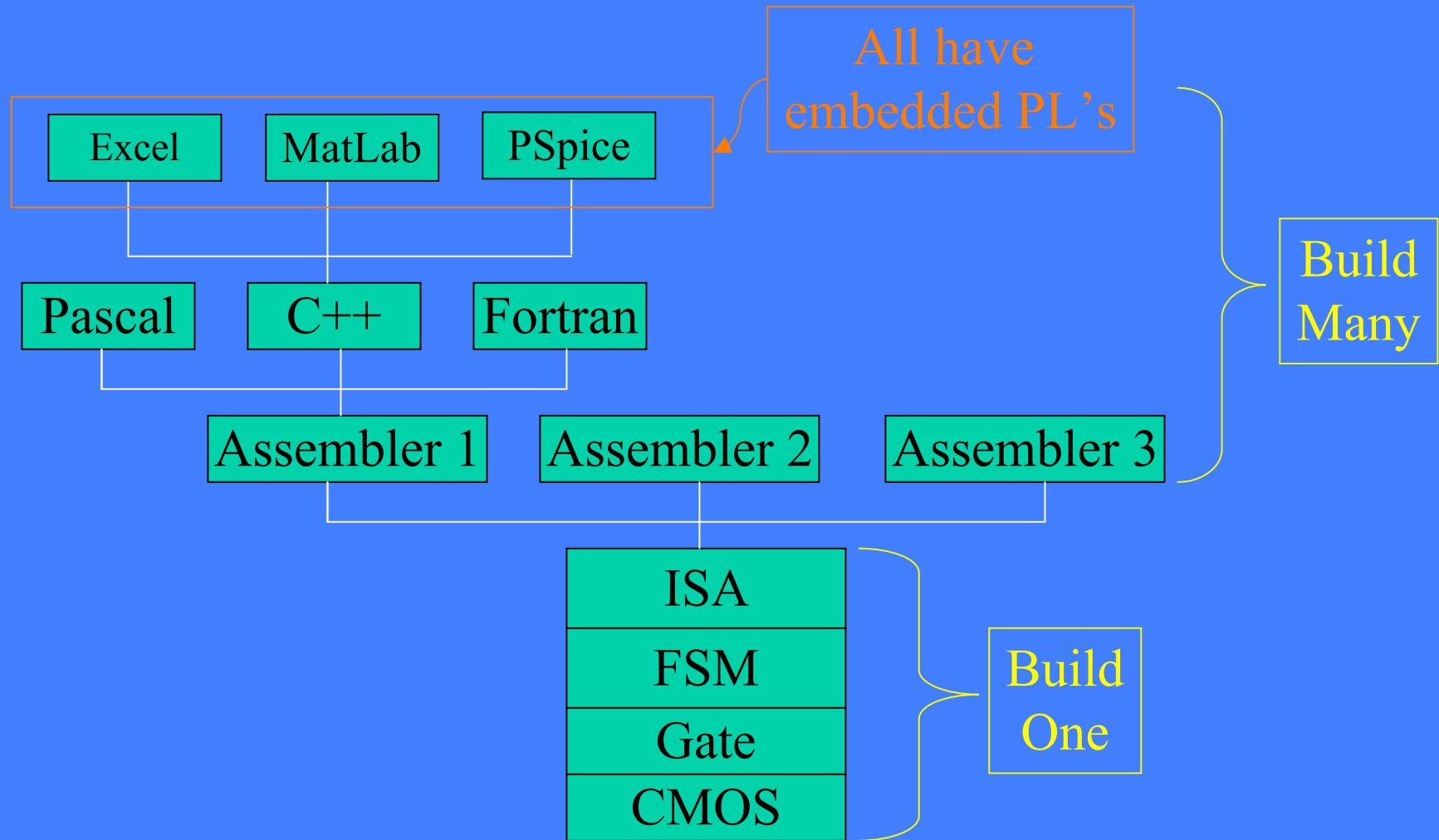


# Other Familiar Models of Computation

- Combinational Circuits
- Sequential Circuits (FSM's)
- Pentium Instruction Set Architectures
- Lambda Calculus
- Recursive Functions
- C++

Can you tell which ones are Turing Universal?  
That is, which ones can emulate any other Turing Machine?

# Computing in Perspective

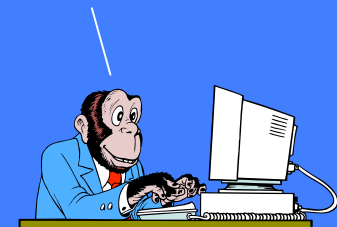


Interpreter Design Demands Programming Language Design

# Why Abstraction Layers?

- Resilience to change:
  - Each layer provides a level of indirection
- Divide and Conquer Approach:
  - Can work on one small semantic gap at a time
- Building Block Approach:
  - Can build many higher layer on same 1

Because we know of no other way of doing anything



# Church's Thesis



**Alonso Church**

“Any realizable computing device can be simulated by a Turing machine”

“All the models of computation yet developed, and all those that may be developed in the future, are equivalent in power.”

Issues not considered: Size, Programmability, Performance  
But they must be considered if one is to build ...

# The (John) Von Neumann Architecture (late 40's)



I/O  
devices

Allow communication  
with outside world



Central  
Processing  
Unit (CPU)

Interprets instructions



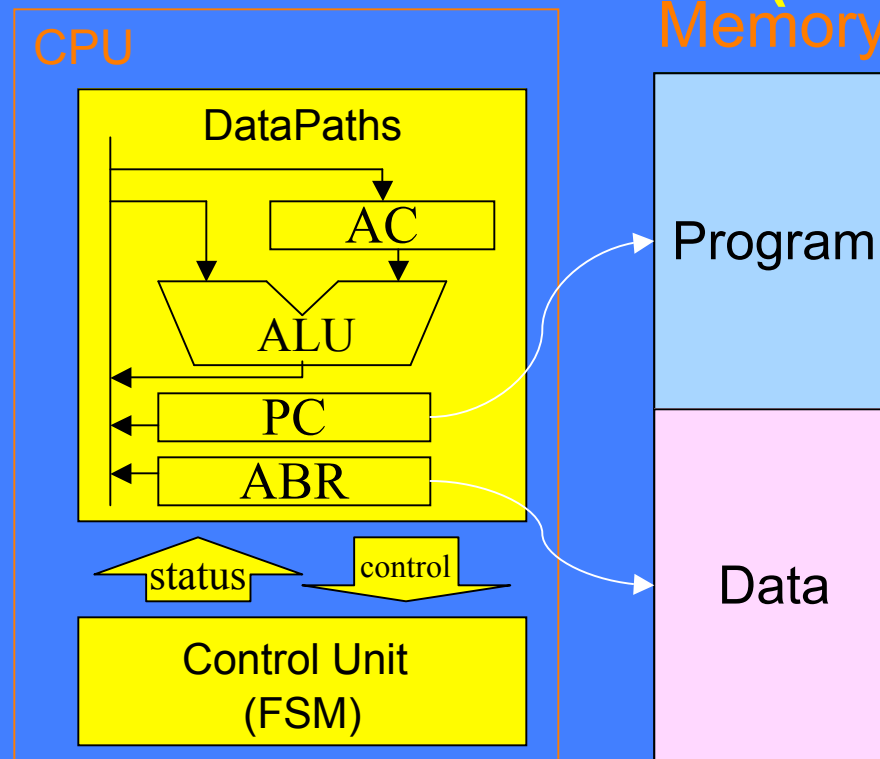
Memory

Stores both programs and data

**After 60 years ... most processors still look like this!**

# Practical Universal Computers

(John) Von Neumann Architecture (1945)



This looks just like a TM Tape



CPU is a universal TM

An interpreter of some programming language (PL)

# End of Lecture 2